Unit–III

Q. 11. ***"Anatomy of plants provides clues with regard to their phylogeny, affinity and taxonomy". Justify.***

Ans. There is a great controversy about the origin of vessel in the Gnetales. It was believed that this group owing to its possession of vessels and the occurrence of broad angiosperm like rays in some species, might prove to be a link between other gymnosperms and angiosperms. The controversy centered round the problem of whether the simple perforations in the end-walls of the vessel elements of the Gnetales and the angiosperms respectively have been developed phylogentically along the same lines. It appeared unlikely that the vessel had precisely the same origin in same groups, because the less advanced perforation plates in the Gnetales are typically foraminate that is pierced by irregularly arranged, circular holes, whereas the corresponding primitive multi-perforate plates of the dicotyledons are scalariform, with regularly arranged, elongated holes.

It is a common thought that the ancestral tracheal element was the tracheid, a long cell with bordered pits, and that vessels have been derived from the tracheids by the disappearance of the pit membrane from some of the pitting in the overlapping walls, thus forming a vertical series of cells that gives an uninterrupted passage for water. Thompson (1918) postulated that the simple perforation of the Gnetales must have been derived from trcheids with sclariform pitting and that therefore there can be no genetic connection of two groups furnish a remarkable instance of the independent development of similar structures.

Bailey (1944), has carried out the ontogenetic studies of the primary and secondary xylem. He considers that the vessels arose first in the secondary xylem and later in the last-formed part of the primary-xylem. He points out that Dicotyledons whose vessels in the secondary wood are very unspecialized often possess vessels in the primary xylem that are distinguishable from scalariform pitted tracheids. He states further that 'the fact that structurally primitive angiosperms had sclariformly pitted tracheids, from which vessels originated, rules out any possibility of deriving the angiosperms from the Gnetales or other representatives of the higher gymnosperms'. According to him the development of the vessels in the Gnetales from circular pitted tracheids is of unique type, and entirely different from the derivation of vessel members from sclariformly bordered pitted tracheids in angiosperms. According to

Bailey, the vessels have originated independently in the Gnetales and Angiosperms.

Frost (1930) correated vessel element length with various other characters, of which the most important was the natural the end-wall. He concluded that the scalariform perforation plate with many hars set in a very unique end wall is the most primitive type because it is associated with the longest vessel members.

Q. 12. ***Give an illustrated account of the structure of the apical meristems in angiosperms.***

Or, ***Write an essay on Apical Meristem.***

Ans. Apical Meristems : The apical meristem lies at the apex of the stem and the root of vascular plants. Very often they are also found at the apices of the leaves. Due to the activity of these meristems, the organs increase in length. The initiations of growth takes place by one or more cells situated at the tip of the organ. These cells always maintain their individuality and position and are called '*apical cells*' or '*apical initials*'. Solitary apical cells occur in pteridophytes, whereas in higher vascular plants they occur in groups which may be terminal and sub-terminal in position.

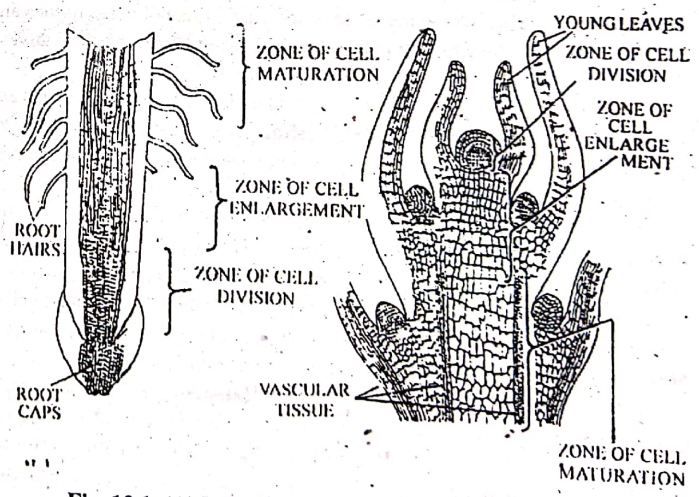

Fig. 12.1. (A) L.S. of root tip sh owing the Zones of growth and differentiation. *(B) L.S. of stem tip showing the similarities with root tip. The differences are seen int he vascular tissue.

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In a young embryo the cells are capable of divisions, but as it matures into an adult, the formation of new cells is restricted to only cerain region. These organized regions of unlimited gowth and cell divisions are called the **"Meristems"**. The term **Meristem** is derived from a Greaek word **meristos** = divisible, was originally introduced by **Nageli** (1858) to designate dividing cells, the meristems are found in such rgions whre active cell division takes place. In plants meristematic activity may take place throughout the life but in animals the cell division is stopped when the animal becomes adult. The meristems in vascvular plants occur at the apices of roots and stems and lateral shoots.

The meristematic cells are spherical or oval in shape lacking the intercellular spaces. Each meristematic cell possesses abundant cytoplasm, a large nucleus and a thin wall. Vacuoles are usually absent but initials of apical meristem and the cambium may have large sized vacuole.

The terms *shoot apex* and *root apex* are more convenient to use instead of apical meristem of the shoot and apical meristem of the root respectively. In the similar way the terms shoot apex and root apex are more conveniently used as the substitutes of growing points. Growth in the sense of cell division, which is characteristic of the meristematic state, is not restricted to the socalled growing point but occurs abundantly—and may be even more intense—at some distance from the apical meristem (Wardlaw, 1945; Goodwin and Stepka, 1945). On the other hand, growth in the sense of increase in size of cells, tissues and organs is most pronounced, not in the apical meristem, but in its derivatives.

Shoot Apical Meristem

The shoot apex has been extensively studied by a number of workers and several theories have been put forward. **Gifford** (1954) has summarised these theories. The following theories have been proposed to explain the structural development and differentiation of the apical meristem.

1. Apical Cell Theory : It was proposed by **Hofmeister** (1857) and supported by **Nageli** (1878). According to this theory the primary meristem develops from a single apical cell e.g., **Crystogames**. Such a single apical cell occurs cell was also believed to the present in seed plants. The apical cell of the Pteridophytes is usually four-sided with three cutting faces but in some e.g. ***Salvia*** and ***Azolla***, it is three sided with two cutting faces.

2. Histogen Theory : It was proposed by **Hanstein** (1870). According to t his theory three distinct meristematic zones can be recognized in the shoot apex of angiosperms. These layers, each of which has its separate of initials, were termed as **histogens**. The outermost histogen was designated as **dermatogen**, the middle one as **periblem** and the innermost as **plerome**. Definite functions were assigned to each histogen. The dermatogen is destined to give rise to the epidermis, the periblem to the cortex and the plerome to the central

cylinder. Subsequent studies revealed that the above layers have no morphological significance as they are not specific in their function. However, in most of the Gymnosperms and Angiosperms. It was not possible to distinguish these layers. Hence this theory which held ground for a long time was later dropped.

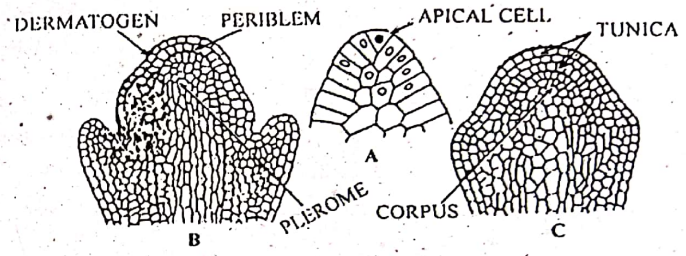

Fig. 12.2. Apical meristem (A) A single apical cell (B) Three histogen layers of Hanstein (C) Tunica and corpus of Schmidt.

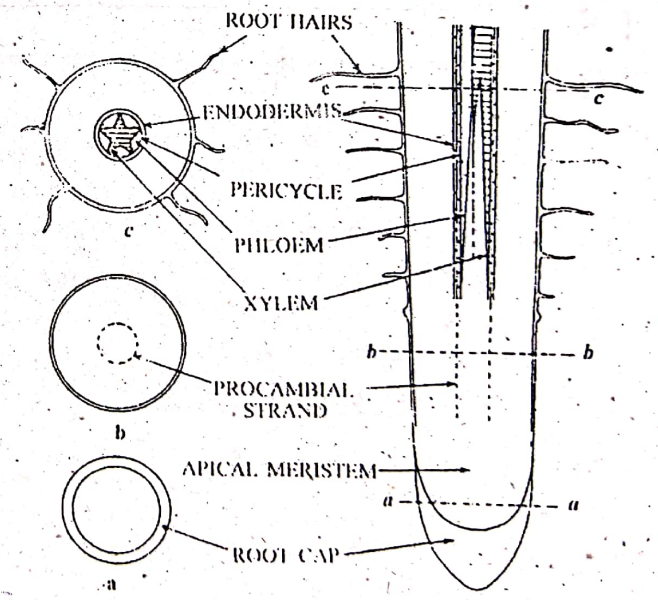

Fig. 12.3. Histogen theory : Position of dermatagen, pariblem and plerome on the shoot apex.

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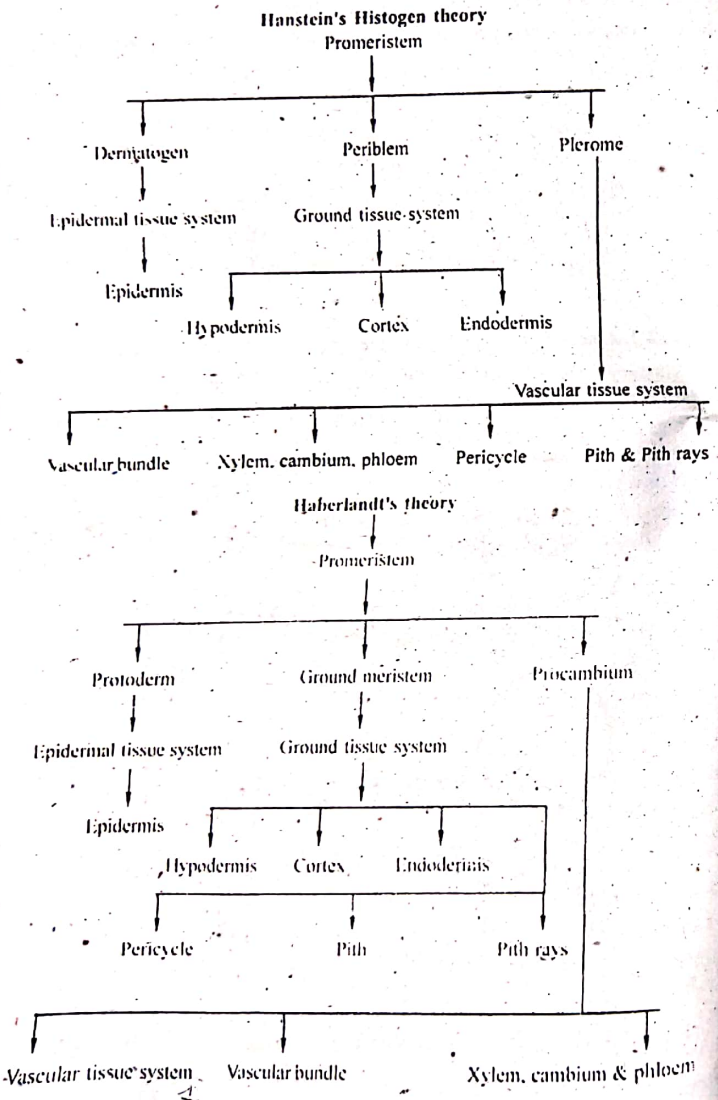
According to **Hanstein and Haberlindt** the meristematic tissues may be compared as follows :



3. The Tunica Corpus Theory : This theory was propounded by **Schmidt** (1924) and was developed a a result of increasing attention towards the development and differentiation of shoot apex.

According to this concept the apical meristem of the stem consists of two more or less well differentiated regions : (1) The **Tunica** which forms the superficial layer and in which the cell divide mostly in an anticlinal manner and (2) the **Corpus** which forms the core of the shoot apex covered by the tunica and in which the cells divide in all planes. In the lower vascular plants, the differentiation between tunica and corpus is poor but in higher plants it has become quite distinct. In any case the tissues at the shoot apex can be differentiated into three more or less distinct regionis.

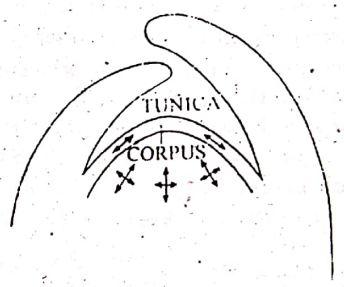


Fig. 12.4. Tunica corpus theory : showing organization of dicot shoot apex.

1. The promeristem or the region of the cell division.
2. The region of enlargment.
3. The region of maturation.

The region of cell enlargement lies just behind the promeristem. The derivatives of the **tunica** layer give rise to the **epidermis.** Groups of cell around the central core of cells elongated conspicuously and form procambial strands. In monocots the groups of cells which give rise to the procambial strands are scattered in the ground tissue enclosed by the epidermis.

In each group of procambial strand the inner cells develop spiral and annular thickenings and thus differentiate into the elements of protoxylem. Similarly a few elements of the procambial strands on the outer side develop into sieve-tubes and companion cells whch constitute the protophloem. However, the wall of procambial strands in between the protoxylem and protophloem is sti ll undifferentiated. Still later when the elongation of the procambial strands

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(and also of the protoxylem elements) is complete the procambial elements just outer to the protoxylem develop scalariform, reticulate and pitted thickenings to form the metaxylem. Thus we see that the development of metaxylem is centrifugal leaving the protoxylem in the position. Inside the protophloem, more of the procambial elements form the sieve-tubes, companion cells and phloem parenchyma to form the primary phloem. In dicot stems, some procambial elements which have not yet given up their meristematic capacity remain as such and constitue the intrafascicular cambium is a left over of the apical meristem among the maturing tissues. The former, however, maintains its organic connection with the latter all through the length of the stem.

The drivatives of the **corpus** outer to the maturing procambial strands differentiate into the pericycle, endodermis and the cortex and those inner and latteral to them into the pith and the conjunctive tissue.

Primordia of young leaves arise just behind the promeristem by divisions in the derivatives of the tunica and the superficial layers of the corpus. Similarly the divisions in the tunica layer and the superficial layers of the corpus in the axil of leaves give rise to the primordia of axillary buds. Thus it would be seen that leaves and branches are exogenous in origin, in contrast at the lateral roots which arise by divisions in the pericycle and are thus endogenous in origin.

4. Histogenic Layer Theory

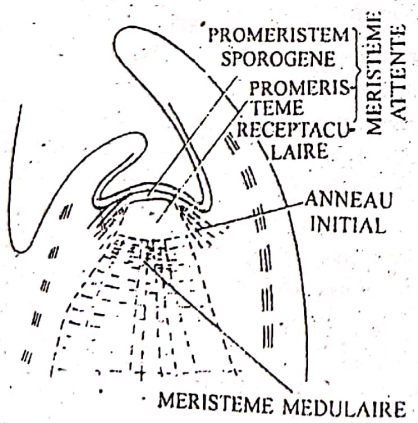

Fig. 12.5. Anneau initial and meristems d' attente theory showing the shoot apex of dicotyledon.

Dermen (1947) induced Peach and Cranberry by colchicine treatment and suggested that tunica corpus may be replaced by **primary** histogenic layers in these cases. According to him in angiosperms there are three L-I, L-II and L-III basic **histogenic layers** which are found in various combinations of ploidy in the shoot apex. The cells of L-I and L-II may be 2X and L-III of 4X, which may form various combinations. From L-I layer, the epidermis o f stem & leaves are formed. The L-II layer forms 2-3 layered hypodermis or cortical tissues or in some cases a portion of vascular tissue. Usually L-III layer forms vascular tissue & pith. Therefore this th eory is regarded as the modification of **Hansteins** histogen theory.

5. Anneau Initial and Meristeme d' Attente Theory

This theory was given by **Buvat** (1955) which explains that during the vegetative phase of development, the peripheral and subterminal regions are actual initiating zones and the distal group of cells comparatively inactive which has no histogenic function. There are three apical meristems i.e., (i) **Anneau initial**—which is active peripheral zone, (ii) **Meristeme d'** attente—which is called waiting meristem and becomes active at the time of inflorescence formation and (iii) **Meristeme medullair**—which is called the central pith region.

According to this theory the centrally situated cells called waiting meristem were regarded as apical initials. **Ball** (1955), **Cutter** (1959) and **Loiseau** (1959) have explained that the waiting meristem divides actively and gives rise to a complete vegetative shoot.

6. Cyto-histological Zonation

In gymnosperms the shoot apices do not have surface layer which divides by anticlincal divisions. In *Ginkgo biloba*, according to **Foster** (1939) the shoot apex has certain zones of cytological characteristics, like.

(i) Apical initial group—It has a group of initials along the apical surface and their **lateral derivatives.**

(ii) Central mother cell Zone—This zone is found below the apical initial group and is formed by them. The cells of this zone have low rate of mitotic activity.

(iii) Rib meristem—It includes the centrally situated mother cells which form the pith.

(iv) Peripheral meristem—The cells of this zone are active & formed the leaf primordia and help in elongation of school.

According to **Popham** and **Chan** (1950) below the youngest leaf primordia a fifth zone is fund which is cup shaped & cealled the **cambium like zone**. This zone is found in *Bellis perennis, Chrysanthemium, morifolium* and *Ricinus communis*. This zone is formed during mid-plastochron and disappears as soon as plastochron comes to an end.

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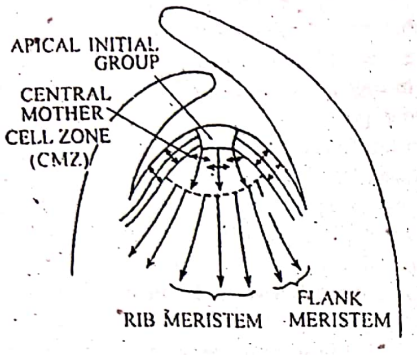

Fig. 12.6. Ginko bilobe : Shoot apex shaowing cyto histological zonation.

7. Regions of Shoot Apex

According to **Wardlaw** (1968) there are following five zones in the shoot apex.

(i) Distal region—It consists a group of initial cells which forms the meristem of the shoot.

(ii) Sub distal region—It forms the superficial layers of meristematic cells where growth takes place.

(iii) Organogenic region—Here the leaf initiation and tissue differentiation takes place.

(iv) Sub apical region—In this region cell division and cell elongation takes place and the internal tissues are differentiated.

(v) Maturation region—When tissue are mature there is no differentiation.

Many anatomists have reported that in the different zones of apical meristems different metabolites are distributed **Gifford** and **Corson** (1971) have found that in the soot apices of Acerpseudoplatanus, histochemical changes are formed due to the seasonal activities. It has been found the amount of R.N.A. is always high in spring and summer which gradually reduces in autumn and winter but there is an increase in lipids and starch. **Gifford** and **Tepper** (1962) worked on seedling apices of *Chenopodium ablum* found that R.N.A., D.N.A. histones and total proteins concentration in the central zone was less than in the cells of peripheral zone. These difference are less when the plant becomes old.

Q. 13. ***Describe role of anatomy in Taxonomy.***

Ans. Anatomy provides evidence concerning the interrelationships of larger groups such as families, or in helping to establish the real affinities of genera of uncertain taxonomic status. Anatomy is of restricted value for distinguishing species or groups of less than specific rank, because the differences between them are usually quantitative rather than qualitative.

Anatomy sometimes proves very helpful for individual identifications. The anatomical methods are of great value in identifying the herbarium specimens which do not bear flowers or fruits. In many cases it becomes possible to assign sterile specimens to a family or a genus. The anatomical methods are also used in the identification of commercial samples of medicinal plants, timbers, fibres, etc. These methods play an important part in checking adulteration, substitution and fraud and sometimes even in detecting the criminals.

It is, however, most important to rely upon anatomical characters of which the taxonomic value has become well established. These characteristics are as follows :

1. Hairs : All taxonomists are familiar with the diversity of external hairs. There are glandular and non-glandular categories, each of which may be subdivided according to the number of component cells, degree of branching, etc. Whole families may frequently be recognized by the occurrence of one or more distinctive types of hair. In other cases, species and genera can also be recognized on the basis of the structure of hair. Smaller variations in size and density should be treated as a basis for the separation of closely related genera and species only after exhaustive investigation of a wide range of material.

2. Stomata : The term stoma means the pair of guard cells together with the aperture between them. The cells surrounding a stoma differing from the remaining epidermal cells are known as subsidiary cells. There are four main types of stomata found in the dicotyledons. These types are—'*ranuculaceous*', '*cruciferous*', '*caryophyllaceous*' and '*rubiaceous*'. These names are given to them after the names of the families in which they were frist observed. Now this has been an established fact that the above mentioned types are found in many other families besides those after which they were originally named. The new terms have also been coined for the above mentioned types.

Type A : Stoma surrounded by a limited number of cells that are indistinguishable in size, shape or form from those of the remainder of the epidermis—the '*ranunculaceous*' or '*anomocytic*' (irregular-celled) type.

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Type B : Stoma surrounded by three cells of which one is distinctly smaller than the other two—the '*cruciferous*' or *anisocytic* (unequal celled) type.

Type C : Stoma accompanied on either side by one or more subsidiary cells parallel to the long axis of the pore and guard cells—the '*rubiaceous*' or *aracytic* (parallel celled) type.

Type D : Stoma enclosed by a pair of subsidiary cells whose common wall is at right angles to the guth cells—the '*caryophyllaceous*' or *diacytic* (cross-celled) type.

The '*gramineous*' type of stoma is believed to be confined to the monocotyledons where it is specially characteristic of the Gramineae and Cyperaceae. The 'gramineous' stoma possesses guard cells of which the middle portions are much narrower than the ends so that the cells appear, in surface view, dumb-bell shaped. The subsidiary cells are found lying parallel to the long axis of the pore.

3. Epidermal cells and hypoderm : Epidermal cells differ considerably in size, shape and outline in different plants. Characters such as a partly or wholly crystalliferous epidermis or the cells with specific chemical contents, are of more importance because of their restricted occurrence. Epidermal cells with vertical or horizontal partitions are of specific or almost generic value, since these features are of restricted occurence.

4. Veins : The comparative structure of the veins of two leaves, and in particular the structure of the vascular bundles and their relationship to the surrounding tissues, it is important to ensure that the veins of the same order are being examined. It is believed, that certain characters of the veins are of confirmatory value in the identification of species and genera. Veins in which the vascular bundles are accompanied on either side by parenchymatous tissue devoid of chlorophyll or by sclerenchymatous or collenchymatous tissue occupying the whole of the space between the bundle and the upper and lower epidermis are described as vertically transcurrent. The possession of these characters, like-vise of specific and generic value.

5. Petiole : The petiole is of considerable taxonomic importance, since its structure is little affected by environment change. to obtain a complete picture of the vascular system of the petiole a series of sections must be cut, and to compare them with sections of the petioles in other leaves.

6. Microchemistry : Several types of chemical deposits occur in plant tissues. These deposits are supposed to be particularly valuable as indicators of taxonomic affinity. The chief types of secretory products are as follows :

(a) Crystals : The most common crystals consist of variously shaped deposits of calcium oxalate. The crystalline secretion such as raphides and crystal-sand are more restricted in distribution and therefore of greater taxonomic interest. Sometimes a whole family is characterized by the secretion of a highly distinctive material. For example, myrosin is quite common in Cruciferae.

(b) Starch : The size, shape and other characters of starch grains are highly distinctive and of considerable taxonomic value.

(c) Cystoliths : The presence of calcium carbonate crystals, the cystoliths is highly characteristics of certain families e.g., Acanthaceae, Urticaceae.

(d) Laticiferous tissue : There is a well developed system of tubes or cells in which variously coloured colloidal fluids known as latex are secreted. The laticiferous elements are of diagnostic value. Since latex is secreted in quite unrelated families its presence does not indicate taxonomic affinity unless this is also supported by other characters.

(e) Secretory elements : Several secretory elements such as resins, oils, mucilage, tannins, etc., are of considerable taxonomic value. These substances are deposited in cells, intercellular cavities, elongated sacs and canals. The canals are often being lined with definite epithelium.

7. Cork : According to Solereder the position in which the cork originates in a young stem is of diagnostic value within limits. In an individual species, the first cork to be formed is often more superficial than that which arises later on. Then again, in a single family there are species which possess either superficial or deep-seated cork respectively, whereas in other families the position of origin of the cork seems to be more constant.

8. Endodermis : The presence of a distinct endodermis in stems is of diagnostic value because of its restricted occurrence. In most dicotyledonous stems the endodermis is inconspicuous. In some the endodermis consists of distinct layer of cells which are differentiated from the neighbouring cells in containing starch. In another group the endodermis consists of cells with well-marked Casparian thickenings. In a few species the endodermis becomes wholly suberized.

9. Sclerenchyma of pericycle : The presence or absence and nature of the sclerenchyma of pericycle is of great diagnostic and taxonomic value. The most common types seen in the transverse sections of the stem are—(i) An interrupted ring of fibres. (ii) A continuous ring of fibres. (iii) An interrupted

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Type B : Stoma surrounded by three cells of which one is distinctly smaller than the other two—the '*cruciferous*' or *anisocytic* (unequal celled) type.

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ring of mixed fibres and stone cells. (iv) A continuous ring of mixed fibres and stone cells, which is commonly known as 'composite, continuous ring of sclerenchyma. (v) Stone cells present, but no fibres. (vi) Sclerenchymatous elements entirely lacking. The nature of pericyclic sclerenchyma plays an important role in separating species or genera in some families, but in a few instances the arrangement may be typical of a whole family. For example, the pericyclic sclerenchyma is not found in all investigated members of Pittosporaceae, whereas a ring of sclerenchyma of a very characteristic type is found in near about all the members of Geraniaceae.

10. Width of medullary rays : The transverse sections of the internodes of young stems of many plants show the widely separated vascular bundles by means of broad parenchymatous tissue, the medullary rays. In Ranunculaceae, these medullary rays are quite broad. In extreme cases the vascular bundles are scattered, e.g., Piperaceae and Berberidaceae. In the transverse sections of other plants, the xylem appears as a closed ring traversed by very narrow medullary rays.

11. Bicollateral bundles : The occurrence of bicollateral vascular bundles in the axis of Cucurbitaceae is of much taxonomic value. In certain families, e.g., Solanaceae, Asclepiadaceae the presence of internal phloem makes a good diagnostic feature.

12. Cortical and medullary bundles, and anomalous secondary thickening : Occurrence of cortical and medullary vascular bundles in various families, genera and species is of diagnostic value on account of their restricted appearance, but the families in which they are found are not closely related to one another.

13. Wood : The characteristics of the wood (xylem) that possess greatest taxonomic value and diagnostic features are categorized as follows :

(a) Vessels : The distribution, pattern diameter and frequency as seen in transverse sections, type of perforation and thickening of vessels are of diagnostic value. The presence of tyloses and the diameter of vessel are of much taxonomic importance.

(b) Wood parenchyma : The types of wood parenchyma, i.e., apotracheal and paratracheal are of much diagnostic value. In apotracheal type distribution is independent of the vessels whereas in paratracheal type distribution is determined primarily by the vessels.

The distribution of wood parenchyma in angiosperms is of two main types i.e., (i) Apotracheal type and (ii) Paratracheal type.

Apotracheal Type :

In such cases the parenchyma cells are not in contact with vessels. This type may be subdivided into three sub types.

(a) Diffuse apotracheal type : In this case the parenchyma cells occur singly among the fibres and tracheids.

(b) Banded apotracheal type : In this case the parenchyma cells occur in bands.

(c) Terminal apotracheal type : In this case the bands of parenchyma cells are confined to the ends of the growth rings (e.g., in Michelia, Acer, etc.)

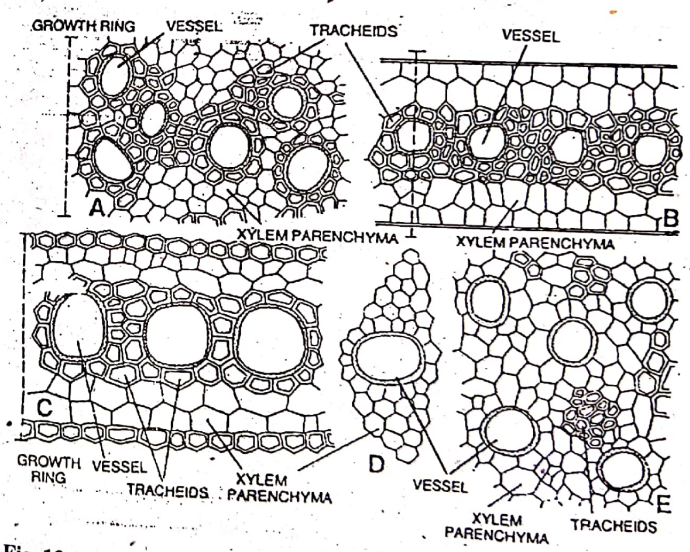

Fig. 13.1 Xylem parenchyma of different types. A, diffuse apotracheal type; B, terminal apotracheal type; C, banded apotracheal type; D, vasicentric ailiform type (also called paratracheal type); E, paratracheal-vasicentric confluent ailiform type.

Paratracheal type :

In such cases the parenchyma cells remain associated with the vessels. This type may be divided into two sub types :

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(a) Abaxial type : Here the parenchyma cells are found in contact with abaxial surfaces of the vessels (i.e., the surfaces away from the centre of the vessel).

(b) Vasicentric type : Here the parenchyma cells completely surrounded the vessel. In certain cases, the surrounding parenchyma cells make wing-like appendages. this type is termed ailiform, vasicentric type (e.g., in some leguminous plants). In still other cases (e.g., in Terminalia). The ringlike extensions around many vessels coalesce and form irregular bands. this type is known as confluent ailiform vasicentric type.

(c) Rays : The width and height of rays are of taxonomic value. Exclusively uniseriate rays is another feature of great value for identification. The frequency of rays is also a diagnostic character.

(d) Fibres : The presence of 'libriform fibres' with simple pits and 'fibre tracheids' with bordered pits is of great taxonomic value.

(e) Storied structure : This consists of the arrangement of the cells or tissues to horizontal series as seen in tangential section.

(f) Growth rings : This character is a standard feature of most descriptions of species.

(g) Included or interxylary phloem : The presence of included phloem in the transverse section of the axis of plant is of diagnostic value.

(h) Intercellular canals : The presence of radial and vertical intercellular canals is of great taxonomic value.

Q. 14. *How will you define the leaf ? Give an illustrated and concise account of the Anatomy of a typical dicotyledonous leaf.*

Ans. The leaf is a specialized organ in which the function of photosynthesis is centered. Leaf is an appendage of the stem but it differs from it in structure.

Usually the leaf is composed of various tissues, which furnish various functions. In discussions of the form and anatomy of the leaf, it is customary to designate the leaf surface that is continuous with the surface of the part of the stem located above the leaf insertion as the *upper, ventral* or *adaxial* side; the opposite sidre s the *lower, dorstil* or *abaxial*.

Commonly there are two types of leaves"1. ***dorsiventral leaves*** (dicotyledonous) and 2. ***isobilateral leaves*** (monocotyledonous). The dorsiventral leaves usually grow in a horizontal direction with distinct upper and lower surfaces, the upper being more strongly illuminated than the lower. There exists a difference in the internal structure between the upper and lower surfaces of the dorsiventral leaf due to its unequal illumination. Most of the dicotyledonous leaves are dorsiventral. The isobilateral leaves hang vertically so that both surfaces of the leaf receive direct and equal amount of sunlight. The isobilateral leaves possess a uniform structure on both upper and lower surfaces. A very few dicotyledons and most monocotyledons have isobilateral leaves.

Anatomy of dicotyledonous leaf

The anatomy (internal structure) of the dicotyledonous leaf is as follows—

Like other organs of a plant, the leaves are also composed of three tissue systems; the dermal (epidermis), the ground (mesophyll) and the vascular (veins) tissue system.

1. Epidermis—The leaf is covered on both surfaces by a single-layered epidermis. The outer walls of the epidermis are usually thickened and covered over with a waxy substance called *cutin*. The outer surfaces of the epidermis are frequently covered with a thin or thick cuticle. This cuticular layer is formed of cutin. The epidermis checks the transpiration to a great extent. The epidermis also prevents the entrance of pathogens into the interior of the leaf. Another function of the epidermis is the protection of the soft internal tissue of the leaf from the mechanical injuries. Sometimes in the xerophytic leaves the epidermal cells become radially elongated and somewhat lignified. In *Nerium* leaf, the epidermis is multilayered.

Numerous small openings, called stomata, are found in the epidermal layers of the leaves. Stomata are found in most abundance in the lower epidermis of the dorsiventral leaf. They are very few in the upper epidermis of the dorsiventral leaf. They are very few in the upper epidermis and sometimes altogether absent. In the floating leaves, stomata remains confined to the upper epidermis; in the submerged leaves the stomata are absent. In xerophytic leaves either stomata are sunken or situated inside the depressions.

Each stoma remains surrounded by two semilunar guard cells. The guard cells are living contain chloroplasts, they regulate opening and closing of stomata. The guard cells may remain surrounded by two or more accessory cells in addition to epidermal cells. The stomata are found in scattered condition.

2. Mesophyll (Meso : middle; phyllon : leaf)

The ground tissue of the leaf, which occurs between the upper and lower epidermis, excluding the veins and consists of soft parenchyma cells, is termed the **mesophyll**. The mesophyll is multilayered and consists of the living cells with chlrop[lasts. The mesophyll may be undifferentiated, as in

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most monocotyledons, containing only one kind of cells. However; in most of the dicotyledons, the mesophyll is differentiated into **palisade** and **spongy tissue.**

(i) Palisade tissue—The palisade tissue is composed of irregular cylindrical cells placed perpendicular to the leaf blade below the upper epiderms. But in isobilateral leaves, it may occur on both sides of the leaf. Chloroplasts are abundantly present, which particularly occur along the radial walls of the cells. n the mesophytes, the palisade tissue consists of only one or two layers of cells. But in xerophytic leaves it may be several layers thick. The palisade tissue is lacunose and the cells are apparently closely arranged. In a longitudinal section the intercellular spaces become quite obvious and it shows that the palisade cells enclose intercellular spaces and they are bathed in an internal atmosphere.

A leaf is green due to the presence of the numerous chlorplasts in the palisade tissue of the leaf. The palisade tissue is a most specialised tissue and forms the principal seat of photosynthesis. The palisade cells, bathed in an internal atmosphere of air, form a seat of carrying efficiently the function of photosynthesis. They are situated usually on the ventral side of the leaf and receives directly the light for photosynthesis.

(ii) Spongy tissue—The sopongy tissue occurs towards the lower epidermis and consists of isobilateral or irregular thin walled parenchyma cells. The cells contain chloroplasts, not so numerous as the palisade cells. But the characteristic feature of the tissue is the enclosure of numerous and large intercellular spaces that contain air as such it has been given the name of a spongy or a ventilating tissue.

The main function of the spongy tissue is to facilitate the free circulation of air in the interior of the leaf and supply of carbon dioxide to the palisade tissue for photosynthesis; and elimination of water vapour, etc. through the stomata to the exterior.

3. Veins or Vascular Tissue—The vascular tissue is composed of vascular bundles which are commonly called veins. There is usually one vein known as the midrib. It's smaller branchs are veinlets. These large and smaller veins form a network which reaches individual cell in the mesophyll.

The vascular bundles are conjoint and collateral and are situated at near the centre of the mid-rib.

Bundle ends : The vascular bundles in leaves terminate in what are known as the **'bundle end'** or vein **endings.**

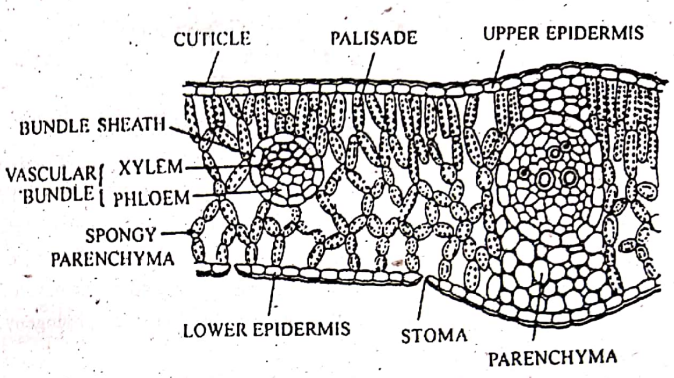

Fig. 14.1. Dorsiventral leaf (leaf of Mango) in tranvserse section.

The bundle sheath. The larger vascular bundles of dicotyledonous leaves remain surrounded by parenchyma with small number of chloroplasts, whereas the small bundles occur in the mesophyll. However, these small bundles do not remain in contact with intercellular spaces but the commonly enclosed within a layer of compactly arranged parenchyma, the *bundle sheath*. In dicotyledons th bundle sheath parenchyma is also called *border parenchyma*. The bundle sheaths of dicotyledonous leaves usually consist of cells elongated parallel with the course of the bundle and having walls as thin as those of adjacent meso phyll. In some plants these cells have chloroplasts similar to those of the mesophyll (e.g., in *Humulus, Nicotiana tobacum*); in others they have few or no chloroplasts. The bundle sheat cells are in direct contact with the conducting cells of the vascular bundle or parenchyma and on the outer face with the mesophyll tissue. Individual sheath cells may contain crystals.

The parenchymatous bundle sheaths are most common, but in certain dicotyldons bundles of various sizes are enclosed in sclerenchyma (e.g., Winteraceae, Melastomaceae; Bailey and Nast.

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